

# STATE OF COLORADO

Roy Romer, Governor  
Patti Shwayder, Executive Director

*Dedicated to protecting and improving the health and environment of the people of Colorado*

## HAZARDOUS MATERIALS AND WASTE MANAGEMENT DIVISION

4300 Cherry Creek Dr S  
Denver, Colorado 80222 1530  
Phone (303) 692-3300  
Fax (303) 759-5355

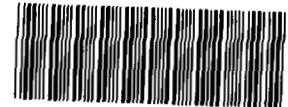
222 S 6th Street, Room 232  
Grand Junction, Colorado 81501-2768  
Phone (303) 248-7164  
Fax (303) 248-7198



Colorado Department  
of Public Health  
and Environment

August 8, 1996

Tim Rehder  
U S Environmental Protection Agency, Region VIII  
999 18th Street, Suite 500, 8EPR-FT  
Denver CO 80202-2405



000066037

### RE Comments on OU 7 Revised Draft IM/IRA Decision Document and Closure Plan

Dear Mr Rehder

The Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division has reviewed the Revised Draft IM/IRA Decision Document and Closure Plan for OU 7. The Division's comments are enclosed. The majority of these comments were previously submitted to DOE at comment resolution meetings in June.

If you have any questions regarding these matters, please contact Carl Spreng at 692-3358.

Sincerely,

Susan Chaki  
Corrective Action Unit Leader  
Federal Facilities Program

cc Dave George, DOE  
Steve Hahn, Kaiser-Hill  
Laurie Peterson-Wright, RMRS  
Bill Fraser, EPA  
Laura Perrault, AGO  
Steve Tarlton, RFPU

T313A

ADMIN RECCRD

A-0007-000-138

1/15

**Colorado Department of Public Health and Environment**

**Hazardous Materials and Waste Management Division**

**Comments on**

**OPERABLE UNIT 7 REVISED DRAFT OU7 IM/IRA DECISION DOCUMENT  
AND CLOSURE PLAN (MARCH 1996)**

---

- 1     Page ES-2  
"Seep Water Discharge to Groundwater" is included with Alternatives 2, 3 and 4. Please replace the above phrase with "Seep Water Discharge Collection and Treatment/Disposal" for Alternatives 2, 3 and 4.
- 2     Page ES-3  
Alternative 2 as described in this text is not considered acceptable. Low permeability zone material used in the cover must have a coefficient of permeability of no more than  $1\text{E-}07$  cm/sec. The exclusive use of a geonet/geotextile geocomposite for the gas collection system is questionable based on the proposed cover configuration and the absence of published studies of the same application at other sites.
- 3     Page ES-3  
The text states "Leachate at the seep would be discharged to alluvial groundwater downgradient of the cap." The above statement should be replaced with, "Leachate at the seep would be collected at the source and treated."
- 4     Page 1-5  
"Leachate collection (and treatment if needed)" is listed as part of the containment presumptive remedy. Please replace "(and treatment if needed)" with "at the source and treatment" in the above item. The revised text should also include leachate treatment as a required component of the presumptive remedy.
- 5     Page 1-6  
Prior to removal of the East Landfill Pond dam, the Dam Safety Branch of the State Engineers Office must be notified (contact Alan Pearson, Principal Engineer). A Notice of Intent to Breach a Dam must be filed with that office.
- 6     Page 2-8  
The text refers to Figure 2-5, which does not show borehole locations as indicated. A figure which indicates the locations of all boreholes should be included in the revised text.
- 7     Page 2-9  
The text states "Flow in unweathered bedrock is so small that any potential contaminant transport occurs by diffusion." However, contaminant transport in unweathered bedrock

may also occur via **advective** flow The above statement needs to clarify that contaminant transport occurs primarily via diffusive transport if that is the intent

8 Page 2-15

A relatively greater quantity of groundwater flowing into the landfill is expected since additional upgradient diversion facilities are now not anticipated This decreased protectiveness should be offset by increasing the cover's factor of safety against infiltration of precipitation Applicable EPA guidance recommendations and standard engineering practice should be used in the selection of optimum cover components

A french drain system may be a reasonable alternative to the slurry wall repair/upgrade project that was previously proposed

9 Page 2-16

The discussion of vegetation fails to address riparian areas Please add the following text from the original version to the revised text "Riparian areas downgradient of the East Landfill Pond are poorly developed and lack extensive woody vegetation Relatively well-developed riparian areas of North Walnut Creek lie approximately one-half mile to the south (DOE 1995c) "

10 Pages 2-21 and 2-25

The rationale for not considering silicon, bicarbonate as  $\text{CaCO}_3$ , carbonate as  $\text{CaCO}_3$ , carbonate, fluoride, orthophosphate, total dissolved solids, total organic carbon, dissolved organic carbon, gross alpha, and gross beta contaminants needs to be included or at least referenced in the text

11 Page 3-2

Potential exposure pathways associated with inhalation and explosion of landfill gas at the Present Landfill should be addressed in the text

12 Page 3-2

See Comment #28 in regards to the discussion of leachate in Section 3.2 - Conceptual Site Model

13 Page 3-3

The statement that, "discharge of leachate contained in groundwater to surface water below the dam is not expected" must be explained and justified

14 Pages 3-3, 3-4, and 3-9

The ecological risk assessment evaluated risks to small mammals via inhalation of volatilized organic compounds in burrows The contribution of landfill leachate to this pathway should be included

15 Page 3-4

Neither the text nor Figure 3-3 adequately addresses what is required for environmental

media that falls into the  $10^{-4}$  to  $10^{-6}$  risk range. The RFCA indicates that soils and groundwater found to be in this range will be managed. Management may include remedial action or further evaluation. The flow chart in Figure 3-3 implies that the response to a risk within this range is exactly the same as to a risk below  $10^{-6}$ .

16 Page 3-6

The MCL and MCLG for barium is 2.0 mg/L, not 2,000 mg/L.

17 Page 3-7

The use of a matrix effect in risk assessment calculations is not allowed and this factor must be deleted from the equations on this page. The paragraphs describing this factor should also be removed from this section.

18 Page 3-12

The ARAR for total iron is 1 mg/L, not 1,000 mg/L.

19 Page 3-14

Under Wetlands Requirements, "Table 3-22" should be referenced instead of "Table 3-20".

20 Table 3-1

Either the units should be changed from mg/L to  $\mu\text{g/L}$ , or the PRG values (except the 2 radionuclides) should be divided by 1,000. A heading for the units column should be included. The radionuclides section header is not centered like the other headers.

21 Table 3-2

Either the units should be changed from mg/L to  $\mu\text{g/L}$ , or the PRG values (except the 2 radionuclides) should be divided by 1,000. Several discrepancies exist between the State surface water standards and the values listed in this table. Table 1 in Attachment 5 of RFCA contains a compilation of the surface water standards to check these values against. Acute standards exist for some of the PCOCs which are footnoted as having no standard available.

22 Table 3-15

Either the units should be changed from mg/L to  $\mu\text{g/L}$ , or the PRG values (except the 2 radionuclides) should be divided by 1,000. Discrepancies exist between the State surface water standards and the values listed in this table. Table 1 in Attachment 5 of RFCA contains a compilation of the surface water standards to check these values against.

23 Figure 3-3

This diagram should be reviewed against the methodology described in Attachment 6 of RFCA, No Action/No Further Action/No Further Remedial Action Decision Criteria for RFETS, and revised as necessary. In particular, "No active response necessary" as a response to risks within the  $1\text{E}-04$  to  $1\text{E}-06$  risk range is inaccurate. While no remedial actions may be required, management actions, including institutional controls may likely be required and are considered to be "active" responses.

24 Page 5-3

4

To a civil engineer, soil is any uncemented or weakly cemented accumulation of mineral particles formed by the weathering of rocks, the void space between the particles containing water and/or air (R F Craig, Soil Mechanics, 1981) It is acknowledged that the permeability of the cover should be less than the 1E-07 cm/sec permeability of the underlying weathered bedrock

25 Page 5-6

The text states, "The Kettleman Hills hazardous waste landfill facility in California successfully used a geonet in 1989 as a biotic barrier for the cover system " Please provide a published study of the above geonet application Also, please provide the geonet manufacturer's recommended applications for their geonet product

26 Page 5-8

The text states, "The HELP model shows an average annual leakage rate of 1 l in /year (Figure 5-4) " Figure 5-4 indicates that there are 9 cover alternatives which is inconsistent with the text This discrepancy should be corrected

27 Page 5-15

The text states, "The presence of the low-permeability (approximately 1E-05 to 1E-07 cm/sec) soil gives the cover system some of the benefits of a composite cover without the rigorous installation requirements of a full compacted clay "

The phrase in parenthesis above should be corrected to read "(less than 1E-05 cm/sec)" to be consistent with the rest of the text

It is debatable that the installation requirements of the "low-permeability" soil would be less rigorous than for clay Please justify or delete references regarding "low-permeability" soils having less rigorous installation requirements than clays

28 Page 5-20

Leachate collection, treatment, and discharge are discussed in Section 5 4 and elsewhere in the text Three options to deal with leachate in general and with the components which cause the leachate to be a listed waste in particular are presented below Any of these options must also include a strategy to address the "relatively high potential for toxic effects [to aquatic life] from chemical concentrations in leachate seep water" mentioned in the final paragraph of Section 3 3 2 on page 3-6

A) Under a formal delisting procedure, the following issues must be addressed by any remedial options dealing with the leachate

- 1 The Present Landfill leachate is itself an F039 listed waste by virtue of its having percolated through multiple hazardous wastes It is not, therefore, a hazardous waste contained in an environmental medium
- 2 The recently-installed leachate collection and treatment system is expected to be able to treat leachate to delistable levels This leachate collection and treatment system

or an alternate long-term treatment system must remain in-place until untreated leachate can be delisted. Continued monitoring must ensure that delisting levels are being maintained.

- 3 To delist treated or untreated leachate, the Colorado Hazardous Waste Commission must be petitioned.

- Follow the requirements in 6 CCR 1007-3 §260.20 and §260.22.

- The petition must include a demonstration that the leachate does not meet any of the criteria under which the waste was listed as a hazardous waste and that other factors, including additional constituents, do not warrant retaining the waste as a hazardous waste. DOE may use a risk basis to prove that the leachate is non-hazardous and to establish delisting levels against which all constituents can be measured. Normally risk levels must be  $< 10^{-6}$  to a residential receptor with a Hazard Index  $< 1$ . If a decision document (e.g., ROD or site-wide agreement) establishes controls that will prevent mismanagement of the particular waste, then an alternative receptor prescribed by that document can be used to calculate conditional delisting levels. That is, on-site treatment of the leachate will allow the use of PPRGs for land uses determined by RFCA as the conditional delisting levels.

- 4 The following items need to be included in this IM/IRA Decision Document, discussed in the Proposed Plan and incorporated into the ROD:

- Delisting method/plan,

- Basis for a conditional de-listing (e.g.,  $10^{-6}$  risk to an open space user), if this basis changes, the determination changes,

- The land use controls which allow a conditional delisting must be specified and established in the final ROD,

- Evidence that the leachate will not violate ARARs,

- Verification testing: description of sample collection methods and frequency, and sample analysis.

- B) As an alternative to a formal delisting process, a comparison against substantive requirements of ARARs, including State surface water/groundwater standards, will be considered sufficient and will constitute a conditional delisting.

The recently-installed leachate collection and treatment system is expected to be able to treat leachate to meet ARARs. This leachate collection and treatment system or an alternate long-term treatment system must remain in-place until untreated leachate can meet ARARs. Continued monitoring must ensure that standards are being maintained.

A plan to address leachate which includes an ARARs analysis and continued monitoring must be included in this IM/IRA Decision Document, discussed in the Proposed Plan and incorporated into the ROD

C) If the leachate outfall is considered a point source discharge under the NPDES permit, then the issue of leachate as a listed waste will be covered by that permit and delisting will not be required. The permit should include State surface water standards as ARARs. It is currently the intention of EPA Region VIII to re-issue the NPDES permit early in 1997, following the December 1996 Colorado Water Quality Control Commission hearing.

The leachate collection and treatment system or an alternate long-term treatment system must remain in-place until untreated leachate can meet ARARs. Continued monitoring must ensure that standards are being maintained.

A description of how leachate will be handled under the NPDES permit must be included in this IM/IRA Decision Document, discussed in the Proposed Plan and incorporated into the ROD.

29 Page 5-27

A release of seep water (F039 listed hazardous waste) to environmental media is not considered a control. Also, burying the seep and intentionally redirecting the seep discharge to groundwater is not considered natural attenuation. The Discharge to Groundwater section must be based on the premise that any discharges will meet ARARs. The currently proposed Rocky Flats Cleanup Agreement incorporates land use controls which prohibit groundwater use. The Agreement, however, does not allow discharging to groundwater in excess of ARARs. The statement that risks to ecological receptors would be eliminated by discharging leachate to groundwater is debatable and should be modified or deleted from the text.

30 Page 6-6

The text states, "A composite made up of geonet with filter fabric on each side will be rolled out over the general fill for gas collection. The geonet will be sandwiched between two layers of filter fabric to prevent fines from clogging the geonet." The geonet apertures will potentially be clogged by filter fabric material when the overlying low permeability zone soil is compacted using heavy equipment.

31 Pages 6-6 and 6-7

A gas venting system is discussed in the Gas-Collection Layer and Overall Protection of Human Health and the Environment sections. The text should state that the gas-collection system will also be configured to convey gas for treatment if needed (as well as for ventilation). The exclusive use of a geonet geocomposite for gas collection does not appear to follow standard engineering practice or EPA guidance. Therefore, the details regarding the geonet geocomposite/gravel column connections must be presented for review.

32 Pages 7-1 and 7-2

The gas collection layer should also be included in lists of cover layers.

33 Page 7-3

A gas treatment system is proposed to be attached to the gravel column vents. This proposed design appears to be somewhat unconventional. The connection details must be presented for review.

34 Page 7-8

The text states, "The only requirements for the general fill are that it is placed and compacted to form an unyielding subgrade for construction of the cover system and that it is sufficiently permeable to allow vertical migration of gases generated in the waste."

The text should also relate that the general fill must not contain deleterious or frozen materials. The general fill will also be subject to compaction specifications.

35 Page 7-8

The text states, "For example, if settlement occurs in the central portion of the landfill, the cover becomes compressed. The physical flexibility properties of the soil and geosynthetic material components allow the cover to sustain minor displacements without rupturing."

The text should relate that cover components will ordinarily experience tension forces in response to settlement. Calculations which support that the proposed geosynthetic cover materials (i.e., FMC, geonet, filter fabrics) will remain intact/functional when subjected to localized settlements of 5.5 ft should be included in the document.

36 Page 7-8

Please provide details about the geosynthetic boots designed to restrict infiltration around pipe penetrations.

37 Page 7-9

This text about seep water discharge to groundwater must include a discussion on how ARARs will be met as mentioned in Comment #28 above.

38 Page 7-9

The text states, "Lateral migration of landfill gas is prevented by the existing slurry wall." The word "mitigated" should be used instead of "prevented."

39 Page 8-1

OU 7 owes its condition as an interim status closure unit to the Rocky Flats RCRA Permit. In order to be complete, this should be mentioned in this section.

40 Page 8-2

In addition to the listed items, the closure plan should also describe leachate collection and treatment. Discharging leachate to groundwater at levels above ARARs is not considered proper disposal.

An estimate of the maximum inventory of hazardous wastes ever on-site over the active life of the facility must be included or referenced in the closure plan. The closure plan must also

include a detailed description of the steps needed to remove or decontaminate all hazardous waste residues and contaminated containment system components, equipment, structures, and soils during partial and final closure, including, but not limited to methods for removing, transporting, treating, storing or disposing of all hazardous waste

41 Page 8-6

Postclosure maintenance activities described in Section 8.2.2 should also include repair of **all** cover components due to **settlement** and erosional damage

42 Page 8-7

There are potential concerns with regard to the proposed point of compliance wells. At least three wells are required to be installed at depths and locations such that they can immediately detect hazardous waste constituents. Well 53194 may be too far away from the landfill to be able to comply with this requirement. Wells 4087 and B206989 are located immediately downgradient of the East Landfill Pond dam and have suffered from the apparent effects of the "dam shadow"

43 Page 8-8

Of the three wells mentioned in the text as upgradient alluvial wells for postclosure monitoring, only Well 70093 appears in Figure 8-2. Please illustrate the other well locations

44 Table 8-3

Iron, Manganese, Phenols, pH, Specific Conductance, Total Organic Carbon and Total Organic Halogen must also be included as groundwater monitoring parameters

**The following are comments regarding DOE's responses to comments made by EPA and CDPHE on the draft OU 7 IM/IRA Decision Document (contained in Appendix J)**

45 EPA J.2.3 Landfill Design Comment 1

Desiccated and fissured clays may have a coefficient of permeability of  $1\text{E-}05$  cm/sec (Soil Mechanics, R. F. Craig, 2nd Edition, 1978) which is equal to that proposed for Alternative E. Clayey gravels typically have a coefficient of permeability greater than  $5\text{E-}08$  cm/sec (Civil Engineering Reference Manual, Fourth Edition, 1986). However, gravels could promote penetration of the overlying FML. The soil type(s) proposed for use in Alternative E must be specified.

Soils compacted at water contents less than optimum ("dry of optimum") tend to have relatively high hydraulic conductivity whereas soils compacted at water contents greater than optimum ("wet of optimum") tend to have a low hydraulic conductivity. It is usually preferable to compact the soil wet of optimum to achieve minimal hydraulic conductivity (Design and Construction of RCRA/ CERCLA Final Covers, EPA/625/4-91/025, Seminar Publication). The ability of fissures or holes to heal in a soil depends largely upon soil moisture content, soil plasticity, the size of the fissure or hole, and ambient stress. Wetter, more plastic soils have a greater healing capability (USDI, 1974) (Design, Construction, and Evaluation of Clay Liners for Waste Management Facilities, EPA/530/SW-86/007F,

November 1988)

The higher the water content of the soil and the higher the plasticity of the soil, the greater is the shrinkage potential from desiccation. There are two ways to provide the required protection after construction. One way is to bury the liner beneath an adequate depth of soil overburden, another technique is to place a geomembrane over the soil. If a geomembrane liner is placed on a soil liner to form a composite, it is often convenient to overbuild the soil liner (i.e., make it thicker than necessary) and then to scrape away a few inches of potentially desiccated surficial soil just before the geomembrane is placed (Design and Construction of RCRA/CERCLA Final Covers, EPA/625/4-91/025, Seminar Publication)

Clay liners may be subject to developing desiccation cracks during and immediately after installation. The clay may be protected from desiccation after construction by installing a synthetic membrane, by installing 1 to 2 feet of soil, or for surface impoundments, by putting liquids into the impoundment immediately after construction (Design, Construction, and Evaluation of Clay Liners for Waste Management Facilities, EPA/538/SW-86/007F, November 1988). Desiccation is not an insurmountable problem and drying of clay can be minimized by using appropriate construction methods and QA/QC procedures.

Also, EPA guidance (Design and Construction of RCRA/CERCLA Final Covers) recommends that the low hydraulic conductivity geomembrane/soil layer be 60 cm (2 feet) as shown in Alternative 9 (Figure 6-4) of the August 24, 1995 draft document. All March 1996 draft document alternatives provide for only one foot depth of "low permeability" soil. An additional foot of material will mitigate desiccation damage thereby increasing protection.

Colorado Hazardous Waste Regulations, 6 CCR 1007-3, Section 265.318(a)(5) states: "At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed and constructed to: Have a Permeability less than or equal to the permeability of any bottom liner system or natural subsoils present." Section 264.301(c)(1)(i)(B) indicates that the compacted soil component of the bottom liner system must have a hydraulic conductivity of no more than  $1\text{E-}07$  cm/sec. The revised draft document indicates that test samples from shallow subsurface soils drilled near the landfill are classified as fat clay (i.e., highly plastic clay). These soils correspond to "impervious" soils, e.g., homogeneous clays below the zone of weathering which have coefficients of permeabilities less than  $1\text{E-}07$  cm/sec (An Introduction to Geotechnical Engineering, Robert D. Holtz and William D. Kovacs, 1981).

Given identical site conditions, a suitably lined landfill would be expected to have less contaminant migration than the present landfill since it will not incorporate a bottom liner. For this reason, it is particularly imperative that cover soils with a coefficient of permeability of no more than  $1\text{E-}07$  cm/sec be used for the low permeability zone layer.

46 EPA J 2.3 Landfill Design Comment 2

Concerns that a highly plastic, high moisture content clay will eventually dry and crack should translate into efforts to determine the evaporative zone depth at the site.

47 EPA J 2 3 Landfill Design Comment 2 (3rd paragraph)  
A  $1 \times 10^{-5}$  "low permeability" soil will also allow considerably more water to infiltrate than a  $1 \times 10^{-7}$  clay

48 EPA J 2 3 Landfill Design Comment 3  
The above response fails to address the original comment regarding the conditions which create the potential for the "bathtub" effect to occur

49 EPA J 2 3 Landfill Design Comment 4  
The response fails to address the original comment regarding giving the advantages of the self-healing properties of clay and the potential for differential settlement adequate consideration in the IM/IRA

Also, the placement of up to 15 feet of fill will tend to increase localized differential settlement rather than to minimize it. The effect of differential settlement will tend to put the liner components into tension rather than compression

50 EPA J 2 3 Landfill Design Comment 7  
The response adds credence to the necessity for requiring chemical compatibility testing of the low permeability zone cover components

51 CDPHE Comment 13  
See comment 23, which discusses various leachate issues

52 CDPHE Comment 15  
It is still unclear how the preferred alternative of discharging the leachate to near-surface groundwater will eliminate this exposure pathway to burrowing mammals

53 CDPHE Comment 21  
A review of Richardson and Koerner (1987) did not find a listing of geonets suitable for use in gas venting systems. On the contrary, the referenced document states, "Geonets are extruded nets formed by extruding and bonding up to three layers of polymer rods oriented at acute angles to each other. They have significant capacity of planar flow and are commonly used with geotextiles to form systems for **leachate or surface water collection/removal**."

Daniel and Koerner (September 1993, Technical Guidance Document QA and QC for Waste Containment Facilities, EPA/600/R-93/182) states: "Geonets are unitized sets of parallel ribs positioned in layers such that **liquid** can be transmitted within their open spaces. Thus their primary function is drainage."

Figure 6-2 indicates exclusive use of a geotextile/geonet/geotextile type geocomposite as a gas collection system which is situated directly beneath the low permeability soil layer. This configuration promotes excessive geotextile intrusion and potential soil intrusion into the geonet apertures (e.g., as a result of overlying soil compaction operations) which could adversely impact flowrate.

Exclusive use of geocomposites which employ a geonet component for the proposed gas collector system is unconventional and unacceptable given the proposed configuration of the cover. EPA guidance (Design and Construction of RCRA/CERCLA Final Covers and Requirements for Hazardous Waste Landfill Design, Construction, and Closure) indicates that a gas collection system composed of perforated pipes encased by granular soils is recommended. Solid pipes (as opposed to gravel columns) are connected to the perforated pipes for gas venting or conveyance to treatment facilities if required.

54 CDPHE Comment 21

The response states, "Once surface water has migrated through the cover section, it will ultimately migrate into the waste, regardless of whether it flows in the gravel columns or directly through the general fill placed to achieve the design surface grades. The only impact of the gravel columns will be to decrease the time for that water to reach the waste."

Surficial moisture must not circumvent the cover barrier system via migration thru the gravel column conduits. Also, gravel columns would be subject to clogging from sediments carried by surficial runoff as it penetrates the cover layers. This situation could adversely impact the effectiveness of the proposed gas collection system. The effectiveness of using gravel columns for transport of landfill gas to a potential treatment system is also questionable. Solid pipes should be used in lieu of gravel columns to convey landfill gas and to inhibit accelerated percolation of surface water into the underlying waste.

55 CDPHE Comment 25

A review of the literature indicates that the frost protection layer in this region should be at least 1.25 meters (Introductory Soil Mechanics and Foundations: Geotechnical Engineering, G. F. Sowers, 4th Edition, 1979). The total depth of the cover materials above the low permeability zone layer should be a minimum of 1.25 meters (4.1 feet). This thickness will also help minimize low permeability zone layer material desiccation after construction.

56 CDPHE Comment 25

The response states: A review of site-specific biologic conditions at OU 7 indicates that a biotic barrier is necessary. However, the geosynthetic drainage layer also serves this purpose.

The proposed geosynthetic drainage layer and the underlying FMC may be subject to damage/malfunction resulting from burrowing animal activity. EPA guidance (Requirements for Hazardous Waste Landfill Design, Construction, and Closure) states: A biotic barrier is a gravel and rock layer designed to prevent the intrusion of burrowing animals into the landfill area. This protection is primarily necessary around the cap but, in some cases, may also be needed at the bottom of the liner. Animals cannot generally penetrate a FMC, but they can widen an existing hole or tear the material where it has wrinkled.

EPA guidance (Design and Construction of RCRA/CERCLA Final Covers) also states: Plant roots or burrowing animals (collectively called biointruders) may disrupt the drainage and the low hydraulic conductivity layers to interfere with the drainage capability of the

layers. A 90-cm (3-ft) biotic barrier of cobbles directly beneath the top vegetation layer may stop the penetration of some deep-rooted plants and the invasion of burrowing animals.

An appropriate biota layer must be included in the cover design to protect the proposed geosynthetic drainage layer. Alternatively, a properly designed cobble/gravel biota layer may also serve as the surface water collection/drainage layer. However, a suitable bedding material would be necessary to protect the underlying FMC.

57 CDPHE Comment 26

The response states: Richardson and Koerner (1987) lists geonets and geotextiles suitable for use in gas venting systems.

See Comment #53 above.

58 CDPHE Comment 30

The response states: The permeability of soils can range from  $1\text{E}+2$  to  $1\text{E}-9$  cm/sec (Cedergren 1977). A soil with a permeability of  $1\text{E}-5$  cm/sec is on the lower end of this range and is indicated as a "poor drainage" material. Therefore, a soil with a permeability of  $1\text{E}-5$  cm/sec can be classified as "low permeability." However, we do realize that there are soils with lower permeabilities.

See reply to Response to EPA J 2 3 Landfill Design Comment 1 (Comment #45 above).

A "poor drainage" soil is a poor drainage soil and is not considered to be a "low permeability" soil. A coefficient of permeability of  $1\text{E}-07$  or less distinguishes "impervious" soils (An Introduction to Geotechnical Engineering, Robert D. Holtz and William D. Kovacs, 1981). We acknowledge that a coefficient of permeability equal to  $1\text{E}-05$  qualifies as a "poor" drainage material. A coefficient of permeability equal to  $1\text{E}-07$  qualifies as a "practically impervious" drainage material (An Introduction to Geotechnical Engineering, Holtz and Kovacs, 1981) and must be used as a minimum criteria for the low permeability zone cover soils.

59 CDPHE Comment 30

The response states: We have selected a low-permeability soil with a permeability classification of  $1\text{E}-5$  to  $1\text{E}-9$  cm/sec because that is a realistic permeability value that any soil could achieve in the long run in a cover application where it is exposed to the effects of weathering.

The above statement is debatable. Capping Option E, which employs a soil with a coefficient of permeability of approximately  $1\text{E}-5$  to  $1\text{E}-7$  (not  $1\text{E}-9$ ) cm/sec, was selected for use in the detailed analysis. However, the low permeability zone layer soil must have a coefficient of permeability of **no more than  $1\text{E}-7$  cm/sec**.

60 CDPHE Comment 30

The suggested use of a GCL was not intended to replace the low-permeability soil but to supplement it. Moreover, modeling indicates that the annual leakage rate of Cover Option

E (Single Barrier FMC with a Low-Permeability Cover) is about 8 000 times greater than the annual leakage rate of Cover Option F (Composite-Barrier FMC and GCL Cover)

61 CDPHE Comment 34

Evidently, further refinement for the design layer material types also needs to occur prior to the Title II design. Frost burial depth is currently being specifically addressed (see Comment #53 above). Evaporation zone depth should also be addressed now since it affects the potential for low permeability zone layer desiccation which is the primary basis given for not selecting compacted clay.

62 CDPHE Comment 35

Compacting a single 1-foot lift of soil materials over geosynthetics may not provide sufficient cushion to prevent geonet damage or eliminate intrusion of adjacent materials into the geonet apertures during construction. Intrusion of adjacent materials into the geonet apertures is also affected by the energy imparted to the overlying soils as a result of required compaction operations. This response also fails to address why installation requirements for the "low permeability" soil would be less rigorous than those of a full clay liner. The document should also state that the CQA plan will also include soil placement practices.

63 CDPHE Comment 36

The comparison of leakage rates as a percent of the average annual rainfall is not valid. This analysis neglects to consider the acute impacts of saturated conditions which prevail during the spring runoff/snowmelt time frame. This analysis also neglects interflow effects. Moreover, the annual leakage rate of Cover Option E (Single-Barrier FMC with a Low-Permeability Cover) is about 16 times greater than the annual leakage rate of Cover Option G (Composite-Barrier FMC and Clay Cover).

64 CDPHE Comment 37

See reply to Response to EPA J 2 3 Landfill Design Comment 1 (Comment #45 above)

65 CDPHE Comment 38

Response to CDPHE Comment 21 states "Some infiltration of gas into the soil layer will occur but the majority of the gas will flow through the openings in the geonet and the geotextile." Also, seasonal fluctuations, capillary action and interflow also may cause groundwater contact with the clay layer. These factors indicate that chemical compatibility of the low permeability zone layer material will be required.

66 CDPHE Comment 39

See reply to Response to CDPHE Comment 35 (Comment #62 above)

67 CDPHE Comment 41

See Comment #28, which discusses various leachate issues.

68 CDPHE Comment 42

See replies to Responses to CDPHE Comments 13, 15 and 41 (Comments #51, #52, and #41 above)

69 CDPHE Comment 48

Settlement is also a function of loads placed above the waste material

70 CDPHE Comment 48

The addition of general fill, construction debris and daily cover soil will either increase loading or increase void space resulting in greater (not less) potential differential settlement. After cover installation, waste consolidation causes (rather than diminishes) differential settlement.

Localized settlements may cause damage to or malfunction of proposed cover components (e.g., geosynthetic materials) which may not be easy to repair.

71 CDPHE Comment 51

The Title II design specifications should also incorporate the manufacturer's installation procedures.

72 CDPHE Comment 52

See replies to Responses to CDPHE Comments 13, 15, and 41 above (Comments #51, #52, and #67).

73 CDPHE Comment 57

See reply to Response to CDPHE Comment 15 (Comment #52 above).